RIU

Direct-seeded rice saves money, water and labour

Validated RNRRS Output.

A suite of new techniques associated with direct-seeding of rice has the potential to secure and sustain India's rice bowl—the Indo Gangetic Plains. The time is ripe for alternatives to transplanted irrigated rice, as the system used now is threatened by increasing shortages of irrigation water, higher energy costs, and the rising cost of labour. Recommendations on managing weeds, and on how and when to plant, have been produced for areas with different soils, rainfall and ploughing methods. Plus, decision-support tools are available for extension workers and farmers that present the choice of technology options for direct-seeded rice in a farmer-friendly way.

Project Ref: **CPP29:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **Natural Resources Institute (NRI), UK**
Source: **Crop Protection Programme**

Document Contents:

Description

CPP29

A. Description of the research output(s)

Research into Use
NR International
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UK

Geographical regions included:

India,

Target Audiences for this content:

Crop farmers,

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Phase 1 (1999-02):

Development of sustainable weed management systems in direct seeded, irrigated rice.

Phase 2 (2003-05):

Promotion of integrated weed management for direct seeded rice in the Gangetic Plains of India

Short version:

Facilitating the adoption of direct-seeded rice by smallholders: sustainable weed management options in the Indo-Gangetic Plains.

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

These outputs were validated by projects funded by the Crop Protection Programme [CPP]. Partner Indian university institutions funded facilities and salaries of collaborating staff. Additional supporting work to validate the use of direct seeding in eastern India has been undertaken by state universities working in collaboration with the IRRI co-ordinated Irrigated Rice Research Consortium (funded by Swiss Development Corporation) and the CGIAR co-ordinated Rice-Wheat Consortium.

3. Provide relevant R numbers or programme development/dissemination reference numbers covering supporting research. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RiUP activities.

R7377 [1999-2002]
R8233 [2003-2005]

Associated projects:

Promotion of cost-effective weed management practices for lowland rice in Bangladesh (R8234) (2003-2005)
Decision support frameworks for weed management in lowland rice in Bangladesh. (R8512) (2005-2006)

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*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 200 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

The outputs contribute to **secure, sustainable productivity** of India's rice bowl – the Indo Gangetic Plains (IGP), where profitability of transplanted irrigated rice is threatened by increasing shortages of irrigation water, higher energy costs, and the escalating cost of labour with the growth of the non-farm economy. By 2005 the project had delivered:

*1. A set of **technology options** for **weed control** in **direct (wet or dry) seeded rice (DSR)** validated on farmers' fields under a range of soil, tillage and rainfall conditions.* Conservation (zero) tillage for rice did not return the same benefits as had been shown for wheat. Shifts in weed species that occur with the change to direct-seeding were identified, weed management options were demonstrated and alternative approaches developed for intransigent weeds in dry years. Activities demonstrated that DSR is able to produce similar yields to transplanted rice as well as being **a cost-saving technology** that saved water and labour.

*2. Improved **information flows** to promote the **adoption** of direct-seeded rice.* Information was communicated directly to farmers through a programme of field days, **on-farm trials**, **farmer-to-farmer exchange**, **participatory evaluation** of results, leaflets and posters in local languages, and articles in the local press. A national workshop (2005, the IRRI Rice Knowledge Bank) communicated findings to farmers, researchers and key decision-makers.

3. ***Decision-support tools.*** Decision frameworks for extension workers and farmers that present the choice of technology options for direct-seeded rice in a farmer-friendly way were developed and tested.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	*Technology*	*Service*	*Process or Methodology*	*Policy*	*Other Please specify*
	X	X			

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

Main commodity: rice, in the rice-wheat, or rice-wheat sugar-cane rotation in the Indo-Gangetic plains.

This output could not be applied to other commodities.

7. What production system(s) does the output(s) focus upon? Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	*High potential*	*Hillsides*	*Forest-Agriculture*	*Peri-urban*	*Land water*	*Tropical moist forest*	*Cross-cutting*
	X						

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	*Irrigated*	*Wetland rice based*	*Smallholder rainfed highland*	*Smallholder rainfed dry/cold*	*Dualistic*	*Coastal artisanal fishing*
	X					

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**). Please specify with what other outputs your output(s) could be clustered.*

Value could be added by clustering with research outputs that focus on (1) Indian national initiatives that promote direct seeding of rice, and (2) rice systems in Bangladesh where DSR has been developed.

1. Indian national initiatives in direct seeding.

Direct seeding of rice is being promoted at the levels of research institute and agricultural universities. Technology options are being promoted through the "Land Grant" model of "demonstration" which tends to impact on the early adopters and often larger farmers. To achieve greater impact on farmers with fewer resources increased emphasis should be placed on participative methods and working with "farmer groups". Greater attention may also be placed on the constraints governing the adoption process for small farmers. KVK centres, run from the agricultural universities, offer greater opportunities to achieve this participative development. Links could also be usefully developed with other national initiatives such as the All India Coordinated Weed Control Program.

2. Rice farming systems in Bangladesh.

Research on weed management for DSR in Bangladesh has focused on the rice-rabi system in north-west Bangladesh [R7471, R8234]. Research spillovers from these projects include the development of hand-pulled seed drills, a manual on herbicide use for extension workers, posters covering safe and efficient use of herbicides, and additional knowledge on changes in weed flora under DSR. There is considerable scope for a synthesis of findings from the India (R7377 and R8233) with those of R7471 and R8234 (Bangladesh) into a decision support framework for integrated weed management for direct seeded rice in irrigated and rainfed rice. Future work will allow the research findings from India and Bangladesh to be distilled to establish decision-tools for improved weed management for transplanted and direct seeded rice and for transition between the two. This would allow knowledge to consolidated and make it accessible in a form that enhances understanding of the new technology, promotion by extension, and adoption by farmers. A joint project workshop in Dhaka (2006) identified scope for collaboration on decision-support tools for farmers and extension workers, and was attended by NARES country representatives from south and south-east Asia.

Validation

B. Validation of the research output(s)

10. How *were the output(s) validated and* ***who*** *validated them?*
Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation (max. 500 words).

Following 'proof of concept' research station trials in phase 1 of the project, validation trials were conducted in Uttaranchal (GBPUAT), Uttar Pradesh (NDUAT, CSAUAT) and Bihar (RAU) in 2003 and 2004. In each state both researcher- and farmer-managed trials were conducted, the sites overall covering a range of agro-ecological zones that reflected from west to east, a) increasing risk of water scarcity (arrival and duration of monsoon rains and access to state irrigation schemes) and b) farmer access to resources This agro-climatic variability provided a platform to test the robustness of the DSR technologies and associated weed management practices and to identify site-specific adoption issues. Validation was conducted by independent groups of researchers at NDUAT, CSAUAT and RAU and by independent farmers and seed producers in each region. Overall, across the three states, validation was completed by four agricultural universities and 257 farmer trials covering 1276 ha over a 6 year period. In the early stages, validation was completed by ‘progressive’ farmers to be followed by farmers having small holdings (< 2 ha). Early adopters were private seed production farms in the region of GBPUAT. In 2006, the seed production farm at GBPUAT very successfully used direct seeding for state seed production.

The sustainability of weed management options was also assessed by examining the observed shifts in the weed flora with prior knowledge obtained from a) data sets complied from on-station trials conducted by GBPUAT over the previous 10 years and b) research elsewhere in S.E. Asia where direct seeding had been practised. Research findings were validated through peer-review by researchers at the World Rice Research Conference, 2004, and the BCPC International Congress on Crop Science and Technology, 2005 as well as two national workshops held in India (2003, 2005)

The project maintained collaborative links with regional networks coordinated by IRRI (the Weed Ecology Working Group, subsequently the Labor Productivity Group of the Irrigated Rice Research Consortium). This enabled result sharing and evaluation by practising national weed scientists and extension workers.

Comparative economic evaluations of results from on-station trials showed that DSR gave higher net returns than transplanted rice (TPR) with equivalent rice yields but substantially reduced costs. Net labour savings with DSR averaged 27 days/ha. Farmer evaluations of on-farm trials confirmed these results and suggested that:

- Farmers with large holdings valued DSR because of its potential for immediate savings in cash costs for rice. Cost savings were seen primarily in terms of tillage and diesel-powered irrigation, rather than in terms of labour, reflecting steep rises in fuel costs and the high cost of servicing tractors.

- Small holder farmers also valued DSR because it reduced risks by making them less dependent on unpredictable monsoon rainfall and the markets for groundwater and draught power.

Technology was evaluated with farmers who had participated in on-farm trials. Participating farmers were not purposely selected. However, they were self-selecting because they were less risk-averse and able and willing to provide land for testing new technology. In Uttaranchal, participating farmers were “non-poor” and included private seed companies. In Uttar Pradesh and Bihar, participating farmers were generally “moderate poor”. They ranged from farmers owning tractors and tubewells to small farmer-sharecroppers who bought water and rented tractors. Most participants were self-sufficient in rice in a normal year.

*11. **Where and when** have the output(s) been validated? Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

The Indo-Gangetic Plains are a high-potential production system. The farming system is predominantly based on an intensive rice-wheat cropping pattern, which in transplanted rice, demands cheap readily available water. The production system is energy-intensive. Tillage is mechanised and irrigation supplied by shallow tubewells and canals. The productivity and sustainability of this system is vital for national food security. India’s population of 1 billion obtain 40 % of their grain supply from this system.

Weed management options for DSR were developed for the Indo-Gangetic Plains as a whole, which occupies 20% of the land area in India, Pakistan, Bangladesh, and Nepal. In this project they were validated only in India, but complementary trials were conducted in Bangladesh (R7471, R8234)

Outputs were tested over 6 seasons in Uttaranchal (2000-05) and over three seasons (2003-05) in eastern Uttar Pradesh and Bihar in farm trials in the following locations.

State	District / Location	Villages	Trials	Area (ha)
Uttaranchal	Udam Singh Nagar, Kashipur	15	93	1088
Uttar Pradesh	Faizabad Kanpur, Sultanpur	4	84	144
Bihar	Patna, Rohtas, Nalanda	4	80	44
Total	-	23	257	1276

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words**).*

Outputs have a wide range of users. Three agricultural Universities are using the outputs to continue research (refine recommendations on herbicide use, monitor changes in weed flora, and measure the impact of DSR on the productivity of the rice-wheat cropping system under different tillage regimes). Agricultural Universities are also promoting the outputs through on-farm demonstrations, field days, and training by extension staff located at the KVK extension centres in three Indian states.

Outputs are being used by large and small farmers and by private companies. In Uttaranchal, the users are primarily large, capitalist farmers and private seed companies that produce rice for the market and recognise that DSR offers them a commercial advantage by reducing costs of irrigation and mechanised tillage. In Uttar Pradesh and Bihar, outputs are being used by small farmers, both to reduce production costs (timely access to irrigation and mechanised tillage is problematic for smaller holders who pay proportionately more for these services than others) and as a strategy to ensure household food security in the face of variable monsoon rainfall.

DSR can be dry-seeded onto soil that has been tilled following early monsoon rains, or wet-seeded onto soils that have been “puddled” as for transplanting following the main monsoon rains. Farmers have generally opted for dry-seeding either because they have access to equipment needed for dry seeding (zero-tillage drills) but no access to equipment needed for wet seeding (drum-seeders), or because they are not aware that wet-seeded rice can be easily grown on a field scale and the weeds managed. Dry-seeding can be used in two situations:

1. When rains allow tillage, land can be prepared and seeded in advance of the main monsoon.
2. When main monsoon rains are late for timely transplanting, land can be irrigated enough to allow tillage and for crop growth rather than puddling prior to transplanting.

Both these options reduce the risk that variable monsoon rainfall will delay rice establishment, which reduces rice yields and also prevents the timely sowing of the following wheat crop, prohibiting yield loss from cold temperatures during the reproductive stage.

Evaluations suggest that many farmers consider only option 1 to be economic, because the cost of irrigating rice, using diesel pumpsets when the ground is still dry, is too high. If the main monsoon rains are delayed this option may considerably reduce risk. Option 2 is only profitable where farmers have electric pumpsets (which pay a fixed charge) or irrigate using state-operated canals (where subsidised water rates are minimal).

Choice of method of DSR to save labour at transplanting therefore varies according to the timing and quantity of the early monsoon rains. When these are sufficient and increase gradually, farmers will dry-seed Conversely, if early monsoon rains develop quickly, then wet seeding (with pre-germinated seed) after puddling is adopted so long as land is levelled to allow adequate drainage for early rice establishment and herbicide efficacy.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

Uttaranchal, eastern Uttar Pradesh, and Bihar states in India.

*14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading **(max 250 words).***

As a direct result of project activities, DSR has been adopted by farmers who have participated in on-farm trials (ca 250) and is being used by University seed farms. It is estimated that over 2000 ha is currently (2006) under DSR since at least 250 ha of direct seeded rice was being grown independently by farmers in 2004, where previously none had been grown, as a result of observation of project activities. The precise number of farmers who have adopted DSR in the target areas is not known but collaborators report DSR is being used by farmers who did not participate in on-farm trials but who have attended project field days or received information about DSR from extension workers who have been trained by the project..

*15. What programmes, platforms, policy, institutional structures exist within the DFID PSA countries to assist with the promotion and/or adoption of the output(s) and in terms of capacity strengthening what do you see as the key facts of success? **(max 350 words).***

The research partners in this project were state-funded Agricultural Universities that follow the US Land Grant model to ensure close links between research and extension. Agriculture departments have large teams of highly qualified staff and universities like GBPUAT and NDUAT have long experience of collaboration with international research institutes and CG centres. Hence, the Indian agricultural universities provide a good institutional base for scaling-up DSR in the region.

Promotion of DSR to date has been through a single pathway. Agricultural Universities operate Krishi Vigyan Kendra (KVK) extension centres located in districts. KVK staff have sufficient funds and transport to travel regularly to provide training farmers in their districts. Activities include field days, demonstrations, and direct response to farmers asking for advice. KVK centres also have equipment (eg. seed drills, spray equipment) that are lent to farmers. Call centres commonly centred in universities (funded by central government) provide free information to farmers based on recommended practices approved by the state agricultural universities and extension service. The centres are outsourced to private contractors, operate from 6 am – 10 pm, and are staffed by agriculture graduates who can answer in the local language. Calls are free. Call centres have internet access to the IRRI Rice Knowledge Bank (RKB).

DSR is also being promoted by private contractors who supply tractor and drill-seeding services. These are farmers who have participated in DSR trials and are using it on their own fields. Farmers contract in advance for fields to be ploughed and dry-seeded. Seed production companies have also been early adopters in Uttaranchal.

There is a strong retail network for herbicides which many farmers already use for transplanted rice. Dealers receive training and information from manufacturers about products they stock.

DSR options are knowledge-intensive technologies and adoption depends on the promotion of an integrated supply chain that will provide farmers with information on DSR and weed management options, together with ready access to the mechanical equipment needed for direct-seeding and the appropriate herbicides particularly in eastern Uttar Pradesh and Bihar. This will require a coordinated effort that brings together extension scientists, KVKs, herbicide manufacturers and dealers, to cement a supply chain that will meet demands for DSR from farmers who have become aware of the technology through trials and demonstrations. The technology will also be promoted by the introduction of cheap reliable drum seeders as are currently being used in West Bengal, Bangladesh and Vietnam.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

The direct environmental benefits include reduced energy use for both mechanised tillage and irrigation water (for dry-seeded rice) and reduced demand for irrigation water for wet-seeded rice. Tillage for dry-seeded rice is reduced because there is no need for repeated ploughing to “puddle” the soil as with transplanting. Instead the soil is tilled with the early monsoon rains and the seed sown and then covered by harrowing. By contrast, wet-seeded rice requires the same tillage as for transplanting.

Irrigation requirements are reduced because rice is direct-seeded onto moist or wet soil rather than transplanted in the form of seedlings. Rice can be established by DSR once 150 mm rain or irrigation water has accumulated compared to 450 mm needed for transplanting. Furthermore, because DSR establishes deeper roots and is more efficient at using soil moisture, less frequent irrigation is required during the growing season. Farmers in Uttar Pradesh who participated in the evaluation of DSR on-farm trials estimated that DSR reduced irrigation costs after crop establishment by one-third. DSR also saves the cost of tillage and irrigation for rice nurseries.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Cost-effective DSR requires the use of pre-emergence herbicides. Herbicides are generally less toxic than insecticides to both humans and the environment, but farmers need more information on how to use them wisely and safely. Inappropriate use of herbicides may lead to the evolution of herbicide resistance in weed species, with devastating impacts on production costs and yields (as has been experienced in weed control in wheat in the IGP). Direct seeded systems face a potential threat from species that are difficult to control. These include *Ischaemum rugosum, Echinochloa crus-galli, E. colona, Leptochloa chinensis,* and *Cyperus* spp.. To avoid these externalities farmers must be provided with information on herbicide resistance management strategies and the value of crop-rotation (especially sugar cane).

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 100 words)***

In particular climate change is expected to increase the variability of monsoon rainfall and the risks of early or late-season drought. DSR increases the capacity of poor farmers to cope with climate induced change by offering a choice of rice establishment methods and by reducing the amount of water required for crop establishment and subsequent crop growth. Further, faced with early drought, farmers can direct seed with minimal soil moisture, rather than wait for sufficient rainfall for transplanting. Earlier crop establishment through DSR also reduces the risk of yield loss from late-season drought, and the cost of additional irrigation to prevent such losses.
